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To Mr. F.J. Kee
Director of Research

SOLAR DOMESTIC WATER HEATING LABORATORY TESTS - COMMERCIAL SYSTEM 'W'

R. Chen and R.A. Solczyk

A drain-back solar domestic water heating system was purchased and installed by a contractor under the supervision of the supplier and the purchaser. The system displaced 38% of the energy required by a standardized hot water load over the December 1981 to August 1982 period. During this period, the system was fully operational. The report includes a description of the system together with a discussion of the operating experience and the measured thermal performance.

1.0 INTRODUCTION

The solar water heating system (System 'W') described in this report was evaluated in the laboratory during Phase II of the Ontario Hydro's solar domestic water heater program. The system was tested to demonstrate its performance and to evaluate the supplier's installation and field support capability.

Solar system 'W' was an indirect system, which relied on a 'drain-back' mechanism for freeze protection. This system consisted of flat plate collectors, a drain-back tank and a preheat tank. A pump was used to circulate the water through the collectors. The pump was activated upon sensing a temperature difference of 11°C between the collector outlet and the preheat tank. When the temperature difference dropped to 3°C, or in case of a power failure, the water returned to the 'drain-back tank' by gravity. A second pump was used to transfer heat to the preheat tank via a heat exchanger. Complete specifications and details of operation are presented in Appendix A. The actual system testing started on December 24, 1981 and terminated on August 9, 1982.

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2.0 INSTALLATION AND COMMISSIONING

A-frames were provided on the roof of the laboratory for the installation of the collectors. The frames faced true south and were tilted at 50 degrees to the horizontal. A 180 L electric water heater was provided as the backup system, and was connected in series with the solar preheat tank. The electric water heater and solar preheat drain-back tank were located inside the laboratory below the collectors. The installation took 27 person-hours of labour.

3.0 METHODS OF TESTING

227 litres of hot water at 60C° were drawn each day from the system according to a standardized draw schedule. The method of testing was the same as for systems 'K' and 'M'/1,2/.

4.0 TEST RESULTS (OPERATION AND PERFORMANCE)

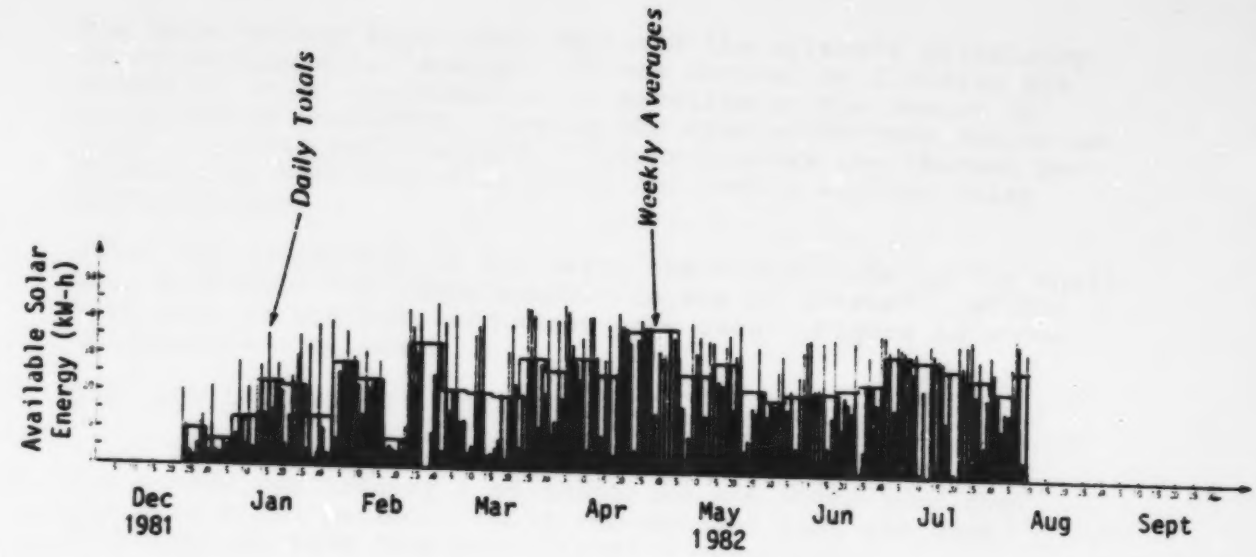
During the nine-month testing period, System 'W' displaced 38% of the electrical energy normally required by the Cascade 40 water heater to heat the standardized hot water draw. The results are summarized in Table 1.

TABLE 1

PERFORMANCE SUMMARY FOR SOLAR SYSTEM 'W'
DECEMBER 24, 1981 TO AUGUST 9, 1982

Test period	201 days
Operational period	201 days
Solar Energy Available*	5000 kWh
Baseline Electric Tank Load	3249 kWh
Solar Contribution to Baseline Electric Tank Load	1233 kWh
Electric Energy Displaced by Solar	38%
Solar Energy Efficiency	25%

* Incident on 5.5 m^2 collector aperture



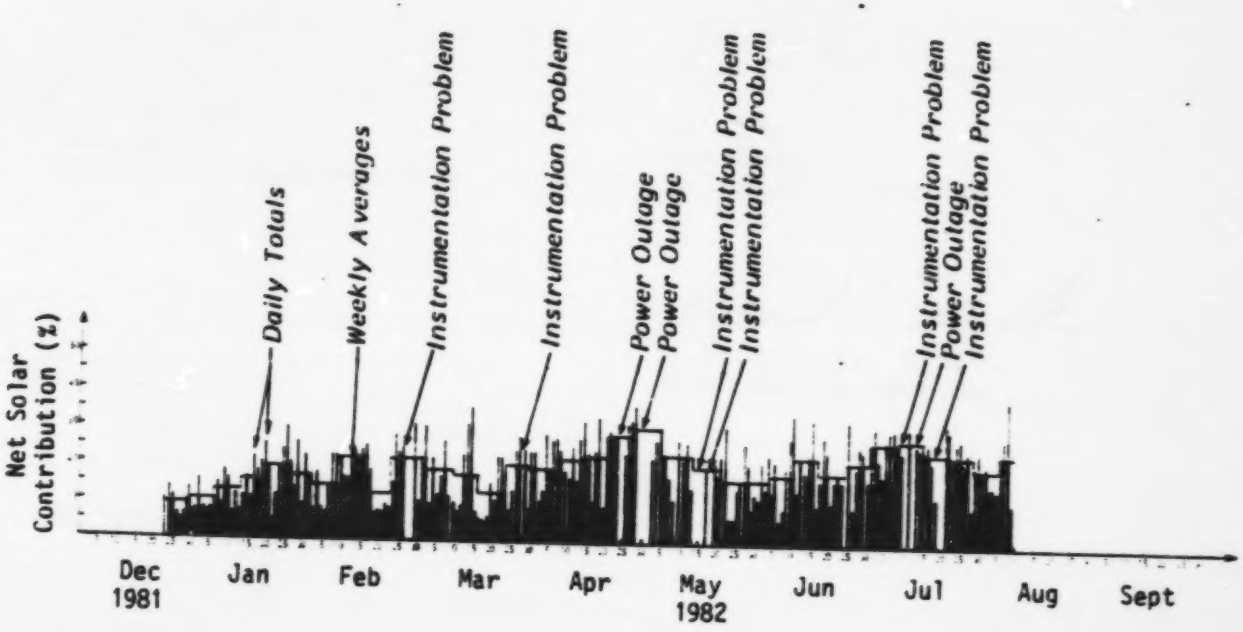


FIGURE 1
SOLAR SYSTEM 'W' PERFORMANCE RESULTS

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The solar energy efficiency measured the system's efficiency in collecting solar energy. It was derived by dividing the amount of solar contribution to baseline by the amount of solar energy available. During the nine month test period no major failures had occurred. Figure 1 shows the thermal performance as both the daily total and weekly average solar contributions.

After the completion of the test, the bronze tube in the shell heat exchanger was taken apart. Layers of corrosion within both ends of the heat exchanger were seen. Figure A4 shows the corrosive buildup.

5.0 CONCLUSIONS

Solar system 'W' performed well. It contributed 38% of the energy required by a standardized hot water load over the nine month period. It is recommended that the heat exchanger be made from non-corrosive materials.

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APPENDIX A

SOLAR SYSTEM 'W' - TECHNICAL DATA AND SEQUENCE OF OPERATION

The arrangement of the major components and the system layout are shown in Figures A1 to A3. The following data characterize the system construction and operation.

Collectors

- Three solar collectors
- Copper finned tubes connected at each end to a header
- 5.5 m^2 total collector aperture
- Low-iron glass
- Collectors plumbed in parallel with reverse return flow connections
- Aluminum outer casing.

Working Fluid

- Heat transfer fluid: water

Collector Flow Rate

- 7/8 L/min

Drain-Back Tank

- 27.3 L capacity drain-back tank lined with glass
- adjustable overtemperature switch
- 25 mm isocyanurate foam insulation

Heat Exchanger

- Tube in shell heat exchanger
- Thermal capacity: ∿4.7 kW.

Preheat Tank

- 227 L glass lined storage tank.
- 76 mm fiberglass thermal insulation.

SEQUENCE OF OPERATION

The two water pumps were turned on and off by a controller according to the temperature difference between the collector outlet and the preheat tank. Both the collector and domestic hot water loop pumps were activated upon sensing an 11°C temperature difference. The energy gained by the collectors was transfered to the preheat tank through an external heat exchanger. Upon sensing a temperature difference of 3°C, both pumps were shut off by the controller, and the water in the collector loop fell back into the drain-back tank.

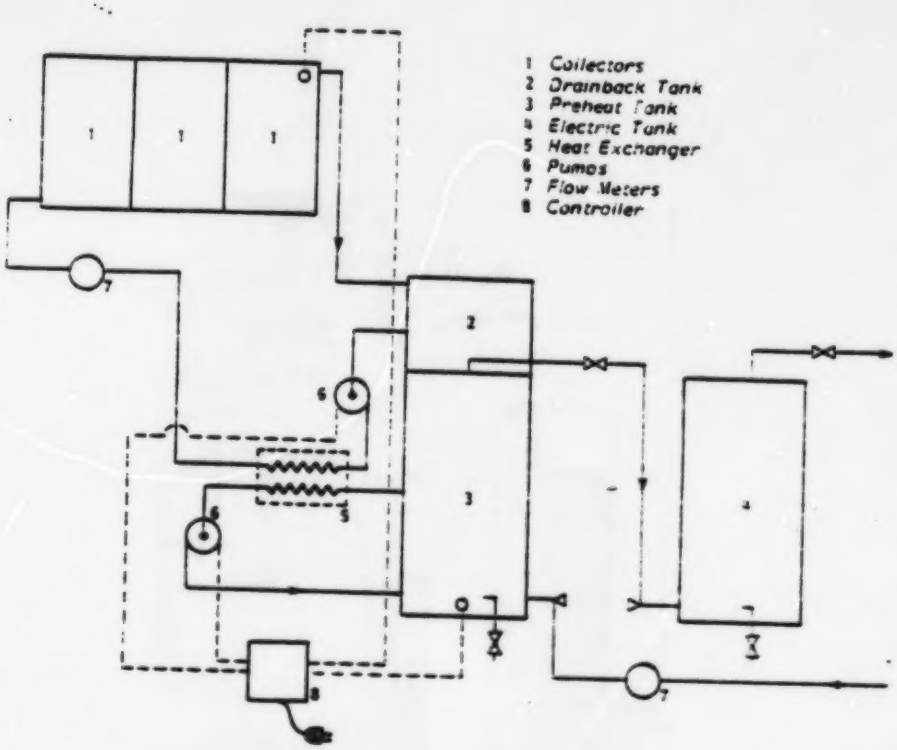

FIGURE A1
SOLAR SYSTEM 'W' - SCHEMATIC DIAGRAM

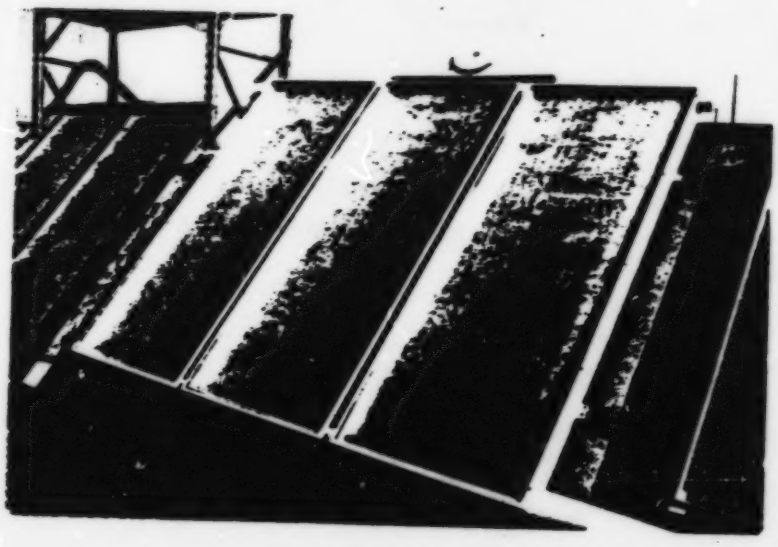

FIGURE A2
SOLAR SYSTEM 'W' - COLLECTORS

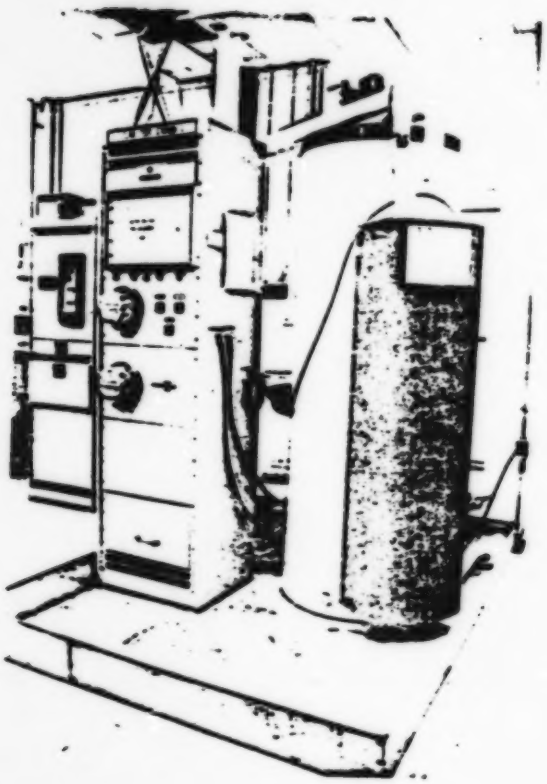

FIGURE A3
TANKS AND CONTROL PACKAGE

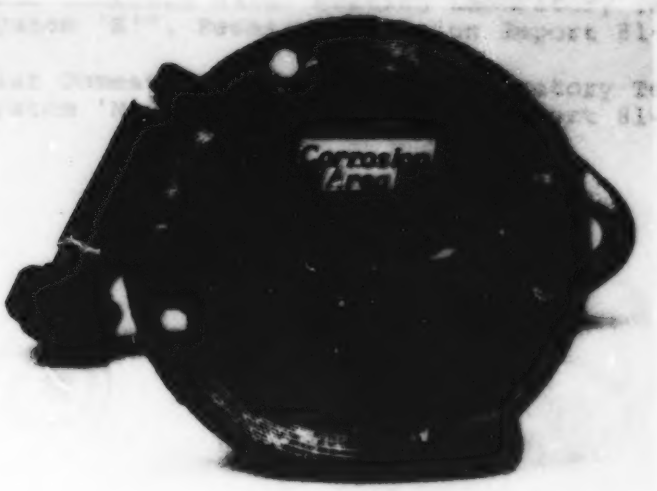

FIGURE A4
CORROSION ON THE HEAT EXCHANGER

REFERENCES

1. R. Chen, "Solar Domestic Water Heating Laboratory Tests - Commercial System 'K'", Research Division Report 81-209-K.

2. R. Chen, "Solar Domestic Water Heating Laboratory Tests - Commercial System 'M'", Research Division Report 81-289-K.

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